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ABSTRACT

The relationship between patterns of learning ability and the amount learned under different instructional conditions was studied. Scores for each of 44 Air Force trainees were obtained on several standardized tests of achievement and ability. Each subject then participated and was tested in five learning situations: (1) listening to taped presentations, (2) watching an animated film, (3) reading and working through programed instruction books, (4) manipulating laboratory equipment with a teaching machine presentation, and (5) using another teaching machine with a programed presentation. Differences between scores on associated ability tests were correlated with the difference in gain scores in the various learning situations. Students with relative strength on the Reading Vocabulary subtest of the California Achievement Test were superior to students with relative strength on the Mathematics Fundamentals subtest in learning in highly verbal instructional conditions. Students with relative strength in Mathematics Fundamentals learned more efficiently in laboratory-like situations than students who scored well in Reading Vocabulary. No comparable patterns were revealed with the Verbal and Performance Scales from the Weschler Adult Intelligence Test or the Administrative and Mechanical Scales for the Airman Qualifying Examination. (KB)

AMRL-TR-65-228

SOME INTERACTIONS BETWEEN INDIVIDUAL DIFFERENCES AND MODES OF INSTRUCTION

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FOREWORD

This research represents a portion of the technical development program of the Technical Training Branch, Training Research Division of the Behavioral Sciences Laboratory. The research was documented under Project 1710, "Human Factors in the Design of Training Systems," Task 171007, "Automated Training and Programed Instruction," and was completed during the period January 1964 through March 1965. Dr. Gordon A. Eckstrand was Project Scientist. Dr. Ross L. Morgan was Task Scientist. The work was performed in coordination with the 3320th Retraining Group, Amarillo Air Force Base, Texas, and West Texas State University, Canyon, Texas. The services of West Texas State University were obtained under Contract AF33(615)-1460 of which Mrs. Wilma Jo Bush was Principal Investigator and Dr. Edgar A. Smith was the Air Force Technical Monitor.

Included among the many individuals who contributed to the accomplishment of this study were Col L. Shapiro, Lt Col R. E. Smythe, Capt F. Kennedy, Lt W. Selman, Lt J. A. Anderson, SMS J. Galdiano, MSgt D. O'Daniel, and Mr. E. Smith of the 3320th Retraining Group, and Mr. H. Goldman and Mr. J. A. Wallace of the 3320th Technical Training Center, Amarillo Air Force Base, Texas. Grateful acknowledgement is also made of the contributions of Drs. Kirk A. Johnson, Donald E. Meyer, Ross L. Morgan, and Gordon A. Eckstrand to the initial conceptualization and the preparation of this report.

This technical report has been reviewed and is approved.

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ABSTRACT

This study explored the hypothesis that there is a relationship between patterns of learning ability and the amount learned in different instructional conditions. Scores for each of 44 subjects were obtained on (a) the Reading Vocabulary and the Mathematics Fundamentals subtests of the California Achievement Test, (b) the Administrative and the Mechanical Scales from the Airman Qualifying Examination, and (c) the Verbal and Performance Scales of the Wechsler Adult Intelligence Scale. Each of the 44 subjects also learned in five different training situations. Differences between scores on associated subtests (e.g., Reading Vocabulary minus Mathematics Fundamentals) were correlated with the difference between gain scores obtained in the various learning situations. A significant relationship was observed between the difference on the subtests of the California Achievement Test and the difference between the gain score from lecture-like instruction and the gain score in laboratory-like instruction. The data tended to support the hypothesis that students with relative strength in Reading Vocabulary are superior to students with relative strength in Mathematics Fundamentals when both are required to learn from instructional conditions that are highly verbal. On the other hand, students exhibiting relative strength in Mathematics Fundamentals tend to learn more efficiently in individual laboratory situations than do students showing relative strength in Reading Vocabulary. No comparable patterns were revealed with the scores from the Wechsler Adult Intelligence Test or the Airman Qualifying Examination.

SECTION I

INTRODUCTION

Frequently, aptitude and achievement test scores are interpreted as indicating that a given student is strong in some areas, weak in others, and has a specified general ability to acquire academic content. As McNemar (ref. 8) has indicated, perhaps only this latter point concerning general ability is reliable. However, in spite of the lack of statistical proof, there is an appeal to the notion of benefiting in some way by taking account of other individual differences in training situations (refs. 2, 3, 9). If only on an intuitive level, there does appear to be logic behind the belief that even among persons of the same overall ability, some have better linguistic ability, some appear to have greater capability for mechanical concepts, and some acquire competence in music more rapidly than others.

If these qualitative as well as quantitative differences do exist, then it would also appear possible that the first type of student might have the best probability of success if he engaged in literary pursuits, the second in mechanical or engineering, and the third by considering fields of endeavor related to music. This is the typical vocational guidance approach. However, a second alternative is also available. This is the approach emphasized by the master teacher in elementary schools. Possibly the different probabilities of success are due to the mode of instruction in addition to the content. Possibly the "mechanically oriented" student learns particularly well when content is presented by those instructional modes employed by mechanically oriented instructors.

The second alternative, that individuals with comparable levels of general ability differ in their ability to acquire knowledge presented via different modes, is the subject of this investigation. Students with differing test score patterns completed five abbrevlated training programs with the mode of presentation systematically varied. While these modes are described in detail later in this report, in brief, they include:

a. A presentation using the printed page — a linear programed text.

b. A presentation based on printed material presented by a device and requiring student responses — a scrambled program presented via a teaching machine.

c. A presentation based on listening to auditory material.

d. A presentation using graphic presentation of projected visuals, including animation, accompanied by spoken narrative.

e. A presentation including audio visual presentation and requiring the performance of the actual task.

Presentations a, c, and d were group presentations; b and e were presented individually.

The basic approach of this investigation is to inquire into relative strengths rather than absolute strengths. In terms of learning acquired, the investigation is not how a student's learning compares to some standard, such as passing or failing. Rather, the inquiry is whether or not this student learns more efficiently or more rapidly in one instructional situation than in another. Do students of type A learn more effectively from training situation A' than from B' while students of type B learn more effectively from training situation B' than from A'?

Similarly, the measures of individual differences were based on differences. The comparisons were not those between students who obtained high scores on test A and students who obtained high scores on test B, but between students who obtained higher scores on A than B and students who obtained higher scores on B than on A. For example, students obtaining high scores on a reading test were not compared with a group obtaining high scores on a mathematics test. Rather, students whose reading scores were above their mathematics scores were compared with students whose mathematics scores were above their reading scores. Naturally, in comparing any two tests, many students do about equally well on each. However, usually there are some students

who do exhibit a pattern of strengths and/or weaknesses. Primarily because of this anticipated continuum of scores, comparisons were made using correlations rather than t-tests.

Such an investigation requires difference scores that are obtainable only by subjecting the same students to several tests and to several training conditions. This, unfortunately, requires that different content be used in the various training conditions, confounding "content" with "method." However, to separate them would have led to equally undesirable consequences.

An important aspect of a study such as this could be in the area of social adjustment. Social adjustment often is dependent on mastery of skills which the school holds to be important. In a survey of problems referred to the metropolitan child-guidance centers, Gilbert (ref. 4) noted that achievement in the basic academic skills and school adjustment often become mutually reinforcing. Those who are able to be successful are rewarded, find wholesome satisfactions in what they are doing, are friendly to the school and its values, and are encouraged to invest more of themselves in their school activities. Conversely, those who are not successful in academic activities find little reward in them, perceive themselves negatively, are perceived by their peers negatively, and are thereby unable to see the school or its activities in a constructive manner. The school to them becomes an unfriendly, often persecuting, institution with little opportunity for real satisfactions.

The two specific hypotheses investigated were as follows:

Hypothesis 1: There will be relationships between patterns of learning and patterns of scores obtained previously on standardized achievement tests.

Method of Investigation: To establish the patterns of learning, an individual student's success in learning under one type of instruction will be compared with his own success in learning under another type of instruction. Similarly, the pattern of achievement will be established by comparing one subtest score on a standardized achievement test with another, more specifically, by subtracting the Mathematics Fundamentals score (grade level equivalent) from the Reading Vocabulary score (grade level equivalent) attained on the California Achievement Test. Statistical significance will be determined by testing the null hypothesis regarding product moment coefficients obtained by correlating the obtained differences.

Hypothesis 2: There will be relationships between patterns of learning and patterns of intellectual ability.

Method of Investigation: Similar to hypothesis 1 but with Wechsler Adult Intelligence Scale scores and/or Airman Qualifying Examination scores used in place of the California Achievement Test scores.

SECTION II

PROCEDURE

An objective test was developed for each of the five subject matters to be learned by all students. Prior to the experiment, the tests were administered twice to subjects similar to those used in the research. The first administration indicated that pretest scores could be expected to be low. The second administration furnished data suggesting that testing per se resulted in little or no acquisition of knowledge, i.e., it served as a pretest — no training — posttest control group.

Subjects were selected from the student population of the 3320th Retraining Group, Amarillo Air Force Base, Texas. The Retraining Group mission is to restore and return to duty selected Air Force offenders who have been convicted and sentenced to at least 90 days confinement. The retrainees used in this research were picked according to their availability. In essence, all retrainees in the academic phase of the retraining program were included in the study. In instances in which the experimental program could not use all available retrainees, selection was

made by administrative personnel not involved in the experiment and without knowledge of the details of the experiment. The only requirements for including a retrainee in the program were that his records indicated that he would remain in the retraining program long enough to complete all portions of the study and that he had completed the first 2 weeks of the program. The latter restriction was made to avoid the initial period of adjustment and orientation to the rehabilitation program. The nature of offense, age, ethnic group, education, etc. were not considered in the selection of any member of the experimental population. The range in age was from 17 years to 39 years, with a mean age of 21.9. The range in academic achievement as reflected by the California Achievement Test scores was from grade level 6.4 to grade level 14.4, with a mean of 10.6. The range in IQ, as measured by the Wechsler Adult Intelligence Scale, was from 76 to 130, with a mean IQ of 104.8.

The experimental instruction was administered to four groups of twelve subjects. These groups were designated A, B, C, and D. Each subject was assigned a number (A-1 thru D-12) for anonymity. Each group required 5 weeks to complete the program. Each group completed the program one instructional day before the next group started. Students A-1 through A-4 were used as pilot subjects and not included in the total reported here.

A standard procedure was followed for each presentation to each group of 12 students. Upon entering the experimental room for the first time, each man was assigned a number and a numbered seat. The investigator gave a verbal orientation, explaining the experiment and requesting the cooperation of each student. He explained that they were not required to participate in the program but that all who began the experiment would be expected to complete it.

Following these preliminary procedures, the first learning situation using the Cousino Tape Recorder was begun. The instructional material consisted of seven 15-minute tapes. These tapes were obtained from the National Tape Repository, University of Denver, Denver, Colorado and are recordings of professionally prepared radio programs. No visual aids were employed. The instruction was given to the 12 retrainees as a group. Pretests of the content material for all seven tapes were administered before any of the tapes were played. Immediately after the first tape was completed, the posttest for that tape was administered. The same procedure was followed with the remaining six tapes. The men were given a 10-minute break between the third and fourth tapes. The total time involved in this presentation was 2 hours and 45 minutes.

The tapes selected for this phase of instruction varied in content and style of presentation. They included:

a. Advertising and You

b. Badge of Dishonor

c. Brass in the Orchestra

d. Care, Courtesy, and Caution

e. Johnny Appleseed

f. The Alchemist and the Scholastic

g. Can You Land a Job

The second instructional situation emphasized visual presentation while deemphasizing reading. The subject matter consisted of an animated film-strip presentation with the investigator reading aloud from an accompanying script. Instruction was given to the 12 students as a group. The PerceptoScope was used to project five different film-strips. After pretesting, the first film-strip was used followed by posttesting on that material. The same procedure was followed on the remaining four film-strips.

The film-strips selected for use were:

a. Accidents or Efficiency, Part I

b. The Accident Sequence, Part II

c. Managing a Safe Workplace, Part I

d. Managing a Safe Workplace, Part II

e. Building a Safe Workshop

The above film-strips were selected from the Industrial Safety Series prepared by Perceptual Development Laboratories, St. Louis, Missouri.

The third instructional situation emphasized reading. Two programed texts entitled Small Purchases and Ethical Standards of Conduct, prepared by the Technical Training Division, Amarillo Air Force Base, Texas were used. The texts are in linear form. While each student progressed at his own pace, they were together as a group of twelve. Following the pretesting, each subject was given the Ethical Standards of Conduct programed text. After a 45-minute study period, they were given the posttest. A 10-minute break followed, after which the Small Purchases programed text was studied for 1 hour and 15 minutes. In both instances, covert responding was utilized, i.e., the student was instructed to mentally compose the response but not to write it.

In the fourth phase of instruction, the content was in the field of electronics, specifically, color code reading of resistors, use of a Vacuum Tube Voltmeter, and measurement of resistance using the Vacuum Tube Voltmeter. The Graflex Instructor was used as the presentation device, combining auditory and visual presentations with overt performance. The device is roughly the size of a table model television. Slides are projected onto a rear projection screen. A magnetic tape provides both auditory instructions to the student and inaudible instructions that control the changing of slides and the automatic stopping of the tape recorder. The actual laboratory equipment shown in the slides was also provided to the student. As each step was described and illustrated by the device, the student also completed the step using the actual equipment. The posttest required actual use of the Voltmeter to determine whether or not test resistors were within tolerance as indicated by their color code.

Since only one device was available, individual sessions were conducted for each experimental student (Fig. 1). This training sequence was prepared at the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. The learning period was 1 hour and 50 minutes, including one 10-minute break. Posttesting was accomplished immediately after training.

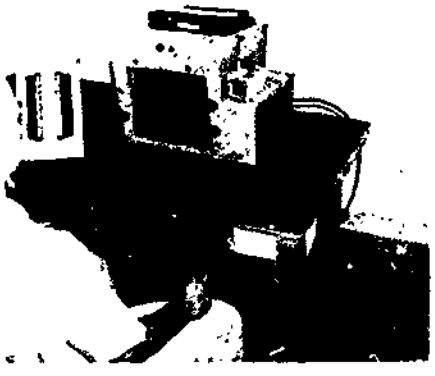

Figure 1. Individual student studying with the aid of The Graflex Instructor.

The fifth phase of instruction was presented through the U. S. Industry Mark II AutoTutor (Fig. 2). Again, only one device was available so individual sessions were conducted. The investigator remained in an adjacent room within call of the student but engaged in other activities. An introduction and pretesting were accomplished at the beginning of the experimental session. The subject matter consisted of the initial portion of Fundamentals of Electronics, prepared at Keesler Air Force Base, Mississippi which is available on microfilm for use in the Autotutor. This material is programed, using the branching technique. The content covers Electrostatics and is basically a historical development of the elementary theory relating to electricity.

The student read the first frame on the device then responded by pressing a button designating his answer to the terminal question. If his answer was correct, the device presented the next frame. If incorrect, the device presents a correctional frame indicating that the answer is incorrect and provides additional explanation. The student must then return to the original question and try again until the correct choice is made. Break periods of 10 minutes were allowed every 50 minutes. After 3 hours and 45 minutes the posttest was administered.

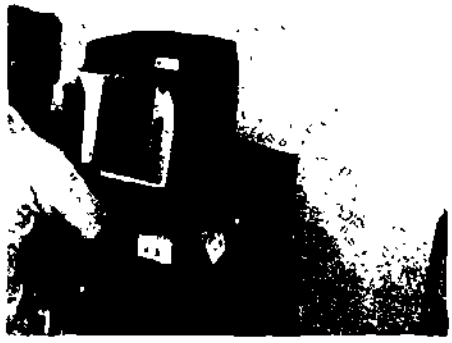

Figure 2. Individual student studying with the aid of the AutoTutor.

SECTION III

RESULTS AND DISCUSSION

Test of Hypothesis I:

The first hypothesis to be tested was, "There will be relationships between patterns of learning and patterns of scores obtained previously on standardized achievement tests." To examine this hypothesis product moment correlations between patterns were computed. Patterns were established by using differences between test scores.

The achievement test pattern was obtained by subtracting the Mathematics Fundamentals score (MF) (grade level equivalent) from the Reading Vocabulary score (RV) obtained from the California Achievement Test. This test is administered routinely to students as they enter the Retraining Group. Testing had been completed less than a month before the students entered the experiment. The selection of these two scores was based on previous experience suggesting that differences between scores are associated with the degree to which students assimilate written material. The directions for the Reading Vocabulary test are, "Mark as you are told the number of the word that means the same or about the same as the first word. Sample: A. Large (1) little (2) big (3)

zero (4) angle." This requires the definition of one word in terms of another word. By contrast, the Arithmetic Fundamentals test contains a minimum of written words. A typical example would be:

$$\begin{array}{r} 471 \\ +\,714. \end{array}$$

Differences between the scores (RV-MF) on all subjects were determined and used as the achievement test pattern.

The pattern of learning was similarly established by subtracting the subject's gain score (post-test minus pretest) from one experimental training situation from his gain score from a second experimental training situation. The results are summarized in Table I.

TABLE I

Correlations Between Difference Gain Scores on Modes of Presentation and Achievement Test Pattern (Reading Vocabulary minus Mathematics Fundamentals)

Audio minus Graflex	.265
PerceptoScope minus Graflex	.431 **
Programed Text minus Graflex	.309 *
Audio minus AutoTutor	.228
PerceptoScope minus AutoTutor	.351 *
Programed Text minus AutoTutor	.299 *
Autotutor minus Graflex	.080
Audio minus Programed Text	-.138
PerceptoScope minus Programed Text	-.023
Audio minus PerceptoScope	-.162

* indicates statistical significance at .05 level

** indicates statistical significance at .01 level

Four of the ten correlations are statistically significant indicating there are grounds for rejecting the null hypothesis. The significant correlations form a rather precise pattern. The PerceptoScope, the Programed text, and the Audio presentations were highly verbal, required rather passive acceptance of information, and were given in a group situation. While the correlations involving Audio are not as high as the others, the direction of correlation is consistent. The highly dramatic nature of the Audio presentations might well have aroused a degree of student participation similar to that of the Graflex and AutoTutor.

By contrast, the Graflex and the AutoTutor modes were both conducted with one subject at a time and the instructor was available for assistance but not otherwise actively engaged in the instructional process, both required a considerable amount of overt participation of the learner. They also involved both verbal instruction and either actual overt activity or covert activity. Both were student paced to the extent that the student probably had a feeling of being on his own.

From this standpoint, it might be appropriate to regard the last four correlations as less critical than the others, since they involve differences between similar instructional situations.

There is also a consistency in terms of content of the subject matter material. The content presented via program text, audiotape, and the PerceptoScope tended to be administrative, verbal, and of general nature. By contrast, the content presented on the Graflex and AutoTutor was oriented toward hardware, toward science (electronics) and emphasized precision and calculations, or measurement.

The significant correlations imply that the greater the superiority of Reading Vocabulary over Mathematics Fundamentals, the greater the superiority of the gain score from lecture-like instruction over the gain score in laboratory-like instruction. Thus, it would seem that students who obtained higher scores on the Reading Vocabulary test than on the Mathematics Fundamentals test also tended to acquire more learning from group instruction using lectures and texts than did students whose mathematics scores were higher than their reading scores. Conversely, students whose achievement test pattern indicated relative strength in the mathematics area, deemphasizing reading, tended to do relatively better in learning in individual laboratory situations than students whose pattern indicated relative strength in reading. The highest correlation involved a contrast between what might be described as a well-illustrated group lecture and an individual laboratory exercise.

This same information is presented in a different form in Table II and figure 3. While none of the differences is statistically significant, this table may afford some clarification and may be of value in interpreting the results described above. The grouping is that described in the appendix. Group 1 was composed of those students who attained Reading Vocabulary scores 1.0, grade level equivalents, higher than their Mathematics Fundamentals score. The Reading Vocabulary score is higher, not necessarily high. Both scores may be high or both may be low or average. Conversely, group 3 contained those students whose attained Mathematics score was at least one full grade above the Reading. Group 2 students were those whose scores were within a grade level of each other. The numbers reported are gain scores, posttest minus pretest.

Table II also presents data relative to achievement and intelligence test results. In terms of overall achievement and intelligence, there was little difference between the groups. The average intelligence scores were remarkably near the national average, tending to be slightly above the population in general. While "out-of-school adult" norms are not available for the achievement test, there is no reason to believe that the groups reported here are particularly below average expectations.

None of these differences is statistically significant. Due to the small number of students, this is to be expected. However, the data do tend to corroborate the significant correlations reported above. The students with relative strength in Vocabulary apparently gained somewhat more than the other students in the Audio, PerceptoScope and the Programed Text presentations. However, in the individual laboratory style instruction, the group with relative strength in Arithmetic appeared to exceed the performance of the group with strength in Vocabulary. No major differences between the groups were observed in the California Achievement Test Total, the AQE General, and the Wechsler Adult Intelligence Scale. While group 3 was consistently above group 1, the differences are slight. To the extent that this reflects a superiority that might be used to account for these students excelling in the AutoTutor and Graflex modes of instruction, it would also be logically required that the difference in the other modes would be increased if the groups were more evenly matched.

Considering the significant correlations presented in Table I and the trends among gain scores shown in figure 3, it seems reasonable to accept the hypothesis that there is an association between achievement test patterns of learning.

TABLE II

Gain Scores Attained in Instructional Situation

	Means				Standard Deviations			
	Group 1 (Higher Vocab)	Group 2	Group 3 (Higher Arith)	Total Pop.	Group 1 (Higher Vocab)	Group 2	Group 3 (Higher Arith)	Total Pop.
Gain Scores								
Audio	19.79	19.60	19.27	19.59	3.61	7.01	5.22	4.99
PerceptoScope	14.44	12.60	13.00	13.64	4.22	4.24	4.06	4.28
Programed Text	25.32	22.70	24.54	24.49	6.73	7.20	8.57	7.40
AutoTutor	6.87	7.00	9.64	7.58	3.97	3.97	5.03	4.42
Grafiex	17.48	18.36	20.36	18.37	4.06	5.25	4.94	4.73
Calif. Ach. Test Grade Level Equivalents								
Read. Vocab.	12.24	10.87	10.06	11.37	1.62	3.28	2.25	2.45
Math. Fund.	8.46	10.76	13.07	10.12	1.65	3.21	2.54	3.02
Total Test	10.32	10.72	11.15	10.61	1.46	2.83	1.76	1.96
AQE -								
General	50.24	52.00	55.45	51.87	18.74	16.16	18.14	18.16
WAIS								
Verbal	103.18	103.40	104.44	103.40	8.41	14.85	9.32	10.40
Performance	105.71	100.50	110.90	105.67	9.56	15.03	10.10	11.72
Total	104.49	102.20	107.72	104.62	8.45	14.07	9.95	10.53
N =	23	10	11	44				

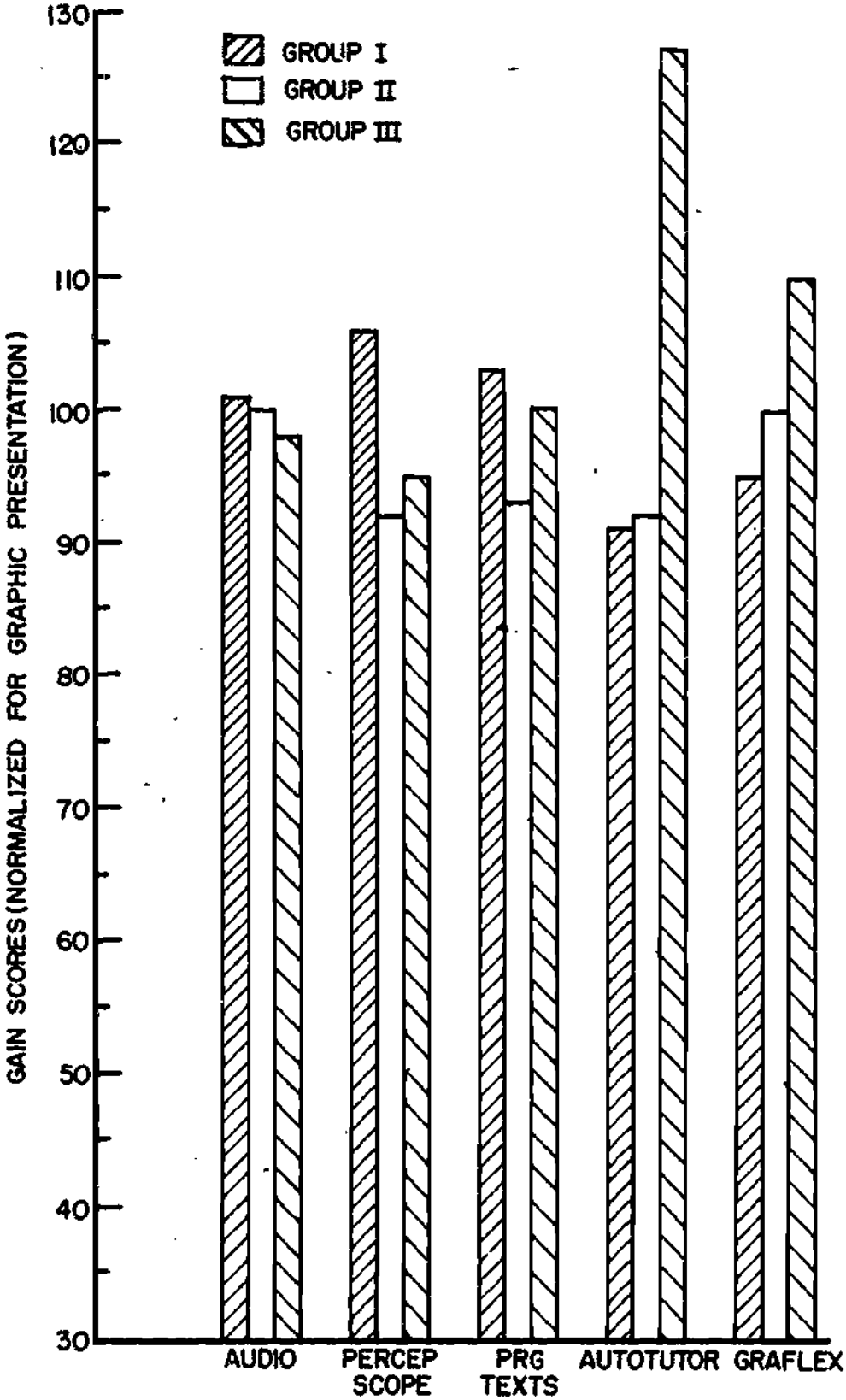

Figure 3. Gain Scores Attained in Instructional Situation

Test of Hypothesis II:

The second hypothesis to be tested was, "There will be relationships between patterns of learning and patterns of intellectual ability." The method of investigation was similar to that used in testing hypothesis I, but ability tests were substituted for achievement tests. The Wechsler Adult Intelligence Scale (WAIS) Verbal and Performance scales and the Airman Qualifying Examination (AQE) Administrative and Mechanical scores were employed. The WAIS is an individual test, the AQE a group test.

Scores for the AQE were available from military records. The WAIS was administered during the experimental period by a qualified examiner not otherwise associated with the experiment. All of these test scores were made available to the investigators after the completion of the training sessions. The results are summarized in Table III.

TABLE III

Correlations between Patterns of Gain Scores and Ability Test Pattern

	WAIS Verbal minus Performance	AQE Administrative minus Mechanical
Audio minus Graflex	-.181	.176
PerceptoScope minus Graflex	.084	.027
Programed Text minus Graflex	-.162	-.001
Audio minus AutoTutor	-.174	.298 *
PerceptoScope minus AutoTutor	.122	.115
Programed Text minus AutoTutor	-.160	.070
AutoTutor minus Graflex	-.037	-.091
Audio minus Programed Text	.032	.163
PerceptoScope minus Programed Text	.263	.021
Audio minus PerceptoScope	-.346 *	.201

* indicates statistical significance at .05 level

Of each set of ten correlations computed, only one is statistically significant at the 5% level. Since it might be anticipated that one of ten correlations would reach this level of significance by chance in half of the sets of ten examined, there does not appear to be sufficient evidence to reject the null hypothesis.

SECTION IV

CONCLUSION

This study explored the hypothesis that there is a relationship between patterns of learning ability and learning acquired in different instructional conditions. More specifically, that in situations where the content and mode of instruction are similar to group lectures one type of student will exhibit more learning while in situations representative of individualized laboratory assignments a different type of student will learn more efficiently.

The investigation appears to support the hypothesis with respect to individual differences reflected in achievement tests, but does not offer similar support for individual differences reflected in either the intelligence test or the Airman Qualifying Examination. A significant relationship was observed between patterns in the difference between Reading Vocabulary and Mathematics Fundamentals test scores and the difference between the gain score from lecture-like instruction and the gain score in laboratory-like instruction. The data tend to support the hypothesis that students with relative strength in Reading Vocabulary are superior to students with relative strength in Mathematics Fundamentals when both are required to learn from instructional conditions that are highly verbal. On the other hand, students exhibiting relative strength in Mathematics Fundamentals tend to learn more efficiently in individual laboratory situations than do students showing relative strength in Reading Vocabulary.

APPENDIX

GENERALITY OF LEARNING IN EXPERIMENTAL POPULATION

As indicated in the body of this report, results of the California Achievement Text, the Airman Qualifying Examination, and the Wechsler Adult Intelligence Scale were made available to the investigators after completion of the experimental training. In addition to the applications described, these results were used to determine whether the learning acquired was relatively general throughout the experimental population or whether it was confined to certain types of students within the population.

To determine the generality of learning, the subjects were grouped into contrasting groups according to differences between subtest scores on each test. On the California Achievement Test, the standard error of measurement for the Reading Vocabulary scale is 0.7 grade level equivalents and that for the Mathematics Fundamentals is 0.8. Subjects with difference scores of + 1.0 and above were grouped to form a Higher Vocabulary group. All subjects with -1.0 and beyond were classed within a Higher Mathematics group. The remaining students who obtained scores differing by less than 1.0 grade equivalent were not included in this comparison.

Differences between pretest and posttest scores were considered to be an index of change occurring during the experiment. The significance of these differences was tested using Student's t. N was the number of pairs of matched pretest and posttest scores. N-1 was the appropriate number of degrees of freedom.

The Airman Qualifying Examination was used in a similar way employing the Administrative and Mechanical scores. Difference scores of 10 or more were the basis for establishing a Higher Administrative Group and a Higher Mechanical Group. Students with less than 10 points differences were not included in either group.

On the Wechsler Adult Intelligence Scale the standard error of measurement on the Verbal Scale is 3.00 and the Performance Scale 3.97. A difference of 5 or more was used to obtain a Higher Verbal and a Higher Performance group. Again students with little or no difference between scores were not included.

Table IV presents data about these groups. All groups appeared to have "learned" from all five experimental conditions. Also note that pretest scores in most instances approached zero.

TABLE IV

Change from Pretest to Posttest in Various Student Subpopulations

Mode of Presentation	California Achievement Test Higher Vocab.	California Achievement Test Higher Math.	Airman Qualifying Examination Higher Admin.	Airman Qualifying Examination Higher Mech.	Wechsler Adult Intelligence Scale Higher Verbal	Wechsler Adult Intelligence Scale Higher Perf.
Audio						
N	23	11	20	12	7	24
Max. Possible	35	35	35	35	35	35
Pretest Mean	.08	.27	.15	.00	.00	.13
Posttest Mean	19.86	19.54	19.65	19.91	22.59	19.50
t	14.23 **	10.03 **	12.42 **	11.71 **	11.29 **	18.99 **
PerceptoScope						
N	23	11	20	12	7	24
Max. Possible	25	25	25	25	25	25
Pretest Mean	.21	.09	.30	.08	.28	.17
Posttest Mean	14.65	13.09	15.10	12.91	14.56	14.21
t	12.44 **	10.15 **	18.04 **	14.25 **	5.47 *	17.40 **
Programed Text						
N	23	11	20	12	7	24
Max. Possible	40	40	40	40	40	40
Pretest Mean	2.30	.82	1.80	2.66	3.28	1.50
Posttest Mean	27.60	25.36	25.45	28.75	29.13	26.66
t	15.42 **	9.02 **	15.35 **	19.91 **	13.18 **	13.60 **
AutoTutor						
N	23	11	20	12	7	24
Max. Possible	30	30	30	30	30	30
Pretest Mean	3.34	2.72	2.00	4.66	4.42	2.33
Posttest Mean	10.21	12.36	10.35	11.16	11.14	10.25
t	8.69 **	6.10 **	7.32 **	7.64 **	4.00 *	8.72 **
Graflex						
N	23	11	20	12	7	24
Pretest Mean	26	26	26	26	26	26
Posttest Mean	.13	.05	.00	.10	.00	.07
t	17.60	20.42	19.32	18.15	16.06	18.59
	18.82 **	13.34 **	22.25 **	11.65 **	6.42 **	16.62 **

* indicates statistical significance at .05 level
** indicates statistical significance at .01 level

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